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REVEGETATION EXPERIMENTAL PROGRAM FOR THE REHABILITATION OF THE RIO BLANCO OIL SHALE TRACT C-a DISPOSAL PILES

U. S. DEPARTMENT OF INTERIOR
OIL SHALE
ENVIRONMENTAL ADVISORY PANEL
Denver Federal Center

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Gulf Mineral Resources Co.
A Division of Gulf Oil Corporation

Standard Oil Company (Indiana)

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9725 East Hampden Avenue
Denver, Colorado 80231
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Rio Blanco Oil Shale Project

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Mr. Peter Rutledge
Area Oil Shale Supervisor
Mesa Federal Savings & Loan
131 N. 6th St. Suite 300
Grand Junction, Colorado 81501

Dear Mr. Rutledge:

Enclosed, for your approval, are two copies of the revegetation program for the rehabilitation of Rio Blanco Oil Shale Tract C-a disposal piles. The revegetation studies were planned in consideration of the planned disposal pile characteristics and in light of the knowledge about revegetation of the area. Although research has been done on methods of revegetating semi-arid lands, more information specific to revegetating the planned disposal pile of tract C-a is needed. Thus, we are proposing a series of long-term studies to fill existing data voids.

Data, having a bearing on the interpretation of the results of the revegetation program but not specific to the revegetation studies (i.e. climatic and trace element information), will be collected concurrent with the revegetation program.

Sincerely,

W T Herget

W. T. Herget

Enclosures:

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REVEGETATION EXPERIMENTAL PROGRAM FOR THE REHABILITATION OF THE RIO BLANCO OIL SHALE TRACT C-a DISPOSAL PILES

INTRODUCTION

The extraction and processing of oil shale rock from Tract C-a will result in the creation of processed oil shale disposal piles. As an integral part of the rehabilitation plans for lands affected by oil shale processing, these disposal piles are to be reclaimed in such a way as to be compatible with the existing landscape and the biota which inhabit it. Revegetation methods should be available at the onset of shale processing to assure that this compatibility is realized. The overall goal of a revegetation plan for Tract C-a disposal piles is to develop self-sustaining plant (and animal) communities in equilibrium with local climate and substrate conditions, and not wholly unlike the existing vegetation. Although considerable research has been done on methods of revegetating semi-arid lands and processed oil shale, it is not specific enough to meet the objectives set forth above for revegetation of Tract C-a disposal piles. Thus, we are proposing a series of long-term experiments to fill existing data voids. The initial revegetation program covered herein is designed to run from fall 1975 through winter 1978. It will involve the application of a number of treatments, such as mulching types, fertilizer schedules, and a species combination to a number of artificially created substrates in field test plots designed to simulate, to some extent, processed shale disposal piles. Based on the results of these

studies, additional experiments will be determined in conjunction with the Area Oil Shale Supervisor.

Pertinent to the revegetation program are the characteristics of processed oil shale disposal piles, as envisioned at this time, which are discussed in the following pages. The design elements are being developed jointly by engineers and ecologists in an attempt to create substrates which are conducive to successful revegetation. Tract C-a revegetation experiments are then discussed in light of the planned disposal pile characteristics and in light of existing knowledge about revegetation of the area and substrates incorporating processed oil shale. A selected bibliography of literature pertinent to revegetation of Tract C-a and adjacent lands is given in Appendix I.

Also bearing on the revegetation program are the existing characteristics of the environment of Tract C-a which are described elsewhere (USDI, 1973; Limnetics, Inc., 1975) and thus will not be discussed here in detail, except where applicable. As part of the Rio Blanco Oil Shale Development Project, baseline environmental studies of Tract C-a have been underway since October 1974 and data generated from these studies will be utilized in designing revegetation experiments as it becomes available (Limnetics, Inc., 1975). In summary, the topography of Tract C-a is characterized by a sub-parallel series of northeast trending canyons and ridges which slope gently northeastward (Figure 1). The slopes of the canyon walls are steep, the valley floors are often

narrow and the ridges are broad and rounded. Altitude within the tract varies from 6,600 feet in Corral Gulch to 7,400 feet on the ridges in the southwest portion of the tract. Maximum relief between valley bottom and adjacent ridges is about 300 feet. Annual precipitation in the vicinity of Tract C-a varies from approximately 10 to 18 inches with higher amounts occurring at upper elevations. About one-half the precipitation occurs as snow from December to April. Spring precipitation is slight, while occasional thunderstorms with accompanying flash floods occur during the latter part of the summer. Temperatures range from near 100°F in summer to -35° in winter.
The frost-free season varies from 124 days at the low elevations to 50 days at the upper elevations in the Piceance Creek Basin and averages about 90 days. Prevailing winds are from a southwesterly direction, but local patterns vary considerably with large-scale atmospheric circulation, topography and time of the day (USDI, 1973).

Soils on the tract are mainly sandy loams and clay loams and are frequently stony (USDI, 1973; SCS, 1975). Most of the soils developed from calcareous sandstones, either as residuum or transported by wind (aeolian), water (alluvium), or slope wash (colluvium). Depths of soils vary with topographic position. Nearly all are mildly alkaline.

Vegetation on the site is predominantly of two types: pinyon-juniper woodland, which occupies the shallowest of soils, and sagebrush, which occurs on somewhat deeper soils in the uplands and better drained alluvial flats.

REVEGETATION EXPERIMENTS

Background Information

As a basis for designing initial revegetation experiments, it was necessary to consider the characteristics of processed oil shale piles to be revegetated and the kinds of information available on revegetation techniques for semi-arid lands and spent oil shale substrates in particular.

Preliminary designs call for a typical disposal pile to have the following strata, from top to bottom:

1/3-1/2 ft of topsoil
1/2-1 ft of subsoil
1-2 ft of crushed rock
2-3 ft of large boulders — "overburden"
5 ft of 95% compacted processed oil shale
0 to several hundred feet of 80% compacted processed oil shale
5 ft of 95% compacted processed oil shale

(The above values represent minimum depths for each strata)

Slopes will be recontoured to blend with the natural landscape, expected to be not more than 33% (3:1) where revegetation is planned.

Catchment basins will be constructed to collect excess runoff. Topsoil substrate and crushed rock will most likely be obtained from the same location as the disposal piles.

The configuration and internal characteristics of disposal piles as described above should provide an adequate quantity and quality of rooting medium to support plant cover comparable to pre-mining conditions. Topsoils will assure reasonable levels of organic matter and nutrients and provide a residual seed and rhizome source while subsoils should retain moisture for utilization during periods when evaporation normally exceeds precipitation. The overburden and/or quarried rock layers are designed to: (1) reduce mass movement of soils, (2) break capillary migration of dissolved salts from the processed oil shale up into the active rooting zone where excess salts could inhibit plant growth, and (3) inhibit contact of roots with spent oil shale where toxic elements may be incorporated into plant tissues and subsequently ingested by herbivores.

Although the precise location of disposal piles resulting from Tract C-a mining has not been determined, preliminary plans suggest that they will be situated in the 84 Mesa area (T1S, R99W, Section 23 and 24), to the northeast of Tract C-a. Soils on the proposed offsite disposal area are similar to those found on the revegetation site (SCS, 1975). The vegetation is predominantly sagebrush and pinyon - juniper.

Technology for revegetating the disposal piles described above is far from adequate. Revegetation experiments conducted to date in other parts of the Piceance Basin have dealt with surficially disturbed soils and processed oil shale, with the latter in some cases covered by a layer of soil (Baker and Duffield, 1974; Block and Kilburn, 1973; Berg, 1975a; Harbert and Berg, 1974; Sims, 1975a, Sims and Redente, 1974). The results of these experiments, while still preliminary in nature, suggest that processed oil shale will be difficult to revegetate directly, and will involve management practices which are designed to leach excess salts from the rooting zone, increase levels of important nutrients (mainly nitrogen and phosphorous), and maintain moisture levels sufficient for germination and establishment. Even when processed oil shale is overlain directly by a considerable depth of soil, there is always the chance that erosion may expose portions of the spent oil shale and thus become the substrate for plant establishment and growth (Berg, 1975b).

With respect to species suitable for revegetation, these earlier studies have concentrated on the performance of species sown in pure stands. It is generally agreed by these same investigators and others that a quality revegetation program should strive for a mixture of species which will provide a greater stability and a greater diversity of food and cover for local fauna than will pure stands (Cook et al., 1974; NAS, 1974; Sims and Redente, 1974).

Design of Experiments

Schedule of Events

Table 1 outlines the schedule of events for the initial revegetation studies on Tract C-a. Field plantings will be made in three successive years starting in the fall of 1975. While both fall and spring sowings may be successful, it has been demonstrated that fall sowings are more successful because of the greater regularity with which moisture is received immediately following the time of sowing (Cook et al., 1974; NAS, 1974).

Location of Test Sites

Location of preferred and alternate test sites are presented in Figure 1. All sites are situated on side slopes, between elevations of 7100 and 7200 ft. adjacent to Wolf Ridge Road in the southeast corner of the tract (T1S, R99N, Section 10). Natural slopes are about 15%, soils are relatively shallow (1-3 ft) fine sandy loams and very channery (platy) fine sandy loams of the Rentsac-Piceance complex (SCS, 1975), and the vegetation is sagebrush. The first year experiments will utilize two sites (preferable R1 and R2) on opposing slopes at comparable elevations and steepness to test for the effect of aspect on revegetation success. Trials in the two subsequent years will utilize a single site on the slope having the more extreme drought conditions of the two original sites tested.

Plot Layout

At a particular site each of the 16 treatments will be applied to a 10-meter x 10-meter plot and replicated three times. Each plot will be surrounded by a 3-meter buffer zone. Treatments will be allocated randomly in each of three complete blocks located adjacent to each other. The total dimensions of a site sample area will be 55m x 165m or 9,075 m^2 (= 0.91 ha. or 2.24 ac.).

Within each 10m x 10m treatment plot, a minimum of three 1m x .5m subplots will be randomly established and marked permanently for subsequent data collection.

Test sites will be fenced with four-strand barbed wire to discourage large grazers, primarily wild horses and cows. Raptor perches will be constructed along the periphery of test sites to discourage concentration of small grazers.

Seedbed Preparation

Native vegetation will be scraped from the two experimental plot sites prior to substrate mixing and transported to adjacent areas for brush piling. Topsoil (about the upper six inches of the soil) and remaining subsoil will be stockpiled separately. The underlying bedrock, consisting of fractured

calcareous sandstone, will be removed for a minimum thickness of 18 inches, broken up, and spread back over the area to simulate overburden. Subsoil and topsoil will then be replaced and graded for sowing. Final grade will approach 3:1.

As part of the site preparation process, an appropriate perimeter will be disturbed around each site, thus bringing the total area of disturbance per site to 4.3 acres or 8.6 acres for two sites (R1 and R2). Materials (topsoil, subsoil, overburden) which are to be stockpiled temporarily (10 days maximum) will be located in the disturbed perimeter.

Sowing Methods

All seed will be drilled into the ground prior to mulching using a conventional grassland drill equipped with a single seed box and agitator. Drilling is preferred to broadcast seeding because less seed is required and greater moisture surrounds the seed during the critical stages of germination (Cook et al., 1974). Drilling will result in a spacing of 5-7 inches between planting rows.

Species and Sowing Rates

A composite mixture of grasses, forbs and woody plants (Table 2) will be sown in preference to pure species stands for reasons stated earlier. This mixture will consist of both introduced and native species. The introduced species, especially the wheatgrasses, are quite aggressive and are thus suited to rapid establishment and stabilization of the substrate (Sims, 1975a). In contrast, the less aggressive native species are generally more successful in later stages of plant community development.

Nearly all the species listed have demonstrated success in earlier trials of germination and establishment when sown in pure stands in the sagebrush ecosystem (Cook et al., 1974; Sims and Redente, 1974). The suitability of each species as wildlife food and cover, as soil stabilizers and as resistors of drought is presented in Table 2. While it would be advisable to utilize local seed sources (NAS, 1974), they are generally not available at this time. For the present studies, it was necessary to obtain seed from a number of private companies and governmental agencies throughout the arid West. Until adequate sources do become available, it may be necessary to maintain some flexibility in the choice of species for revegetation as poor seed producing years are not uncommon, particularly among the longer lived woody perennials (Swift, 1975).

The proportions and absolute sowing rates of species pose a more difficult problem than the selection of species because little research has been done in these areas. For purposes of the 1975 test, it was determined that approximately 16 pounds of seed per acre would be sown, with grasses and non-grasses (forbs and woody plants) in equal 8.1 pound proportions (Table 2) (Sims, 1975b; Cook et al., 1974).

Treatments

For the 1975 test a total of 16 treatments will be applied using all possible combinations of the following variables:

- Mulch Type and Application (applied to cover approximately 70% of the soil surface)

  1. No mulch
  2. Hydromulch with wood fiber
  3. Straw mulch followed by crimping
  4. Straw mulch with netting

- Fertilizer Application (10-5-5 applied at a rate of 160 lbs/acre)

  1. No fertilizer
  2. Fertilizer at time of sowing (fall)
  3. Fertilizer at beginning of first full growing season
  4. Fertilizer at time of sowing and at beginning of first full growing season

Mulches are extremely important in enhancing germination and establishment. They serve not only to retain moisture and reduce surface temperatures, but also aid in reducing erosion and washing away of seeds (Cook et al., 1974; NAS, 1974). The mulches listed above vary considerably in cost of application.

While some have been used extensively in revegetation, the straw mulch with netting has received limited attention. Because of the present lack of detailed soil chemistry data for Tract C-a soils, it was decided that fertilizer rates per acre and the amounts of individual elements (N, P and K) would be held constant for the 1975 trials. Earlier studies have shown that the 10-5-5 balanced fertilizer and 160 lbs/acre rate of application should satis any nutrient deficiencies in Tract C-a soils (Cook et al., 1974). Although potassium is seldom deficient in soils of the region, the 10-5-5 balanced fertilizer was selected because of its general availability.

Plant Response Parameters

The following plant response parameters will be measured for each treatment: (1) number of emerged seedlings per plot, (2) number of surviving seedlings per plot, (3) above ground biomass, (4) percent cover and (5) vigor (Daubenmire, 1968).

Table 3 gives the season of measurement for each parameter and the taxa involved. Photographs will be taken from fixed points in at least one replicate of each treatment at the times of data collection. A qualitative measure of alien species success will be obtained from in-situ counts of germination in buffer areas and from germination rates in soil samples collected from buffer

areas and placed in the greenhouse. In addition, baseline data will be available on plant community composition and structure of the plot areas prior to site preparation (Limnetics, Inc., 1975).

Statistical Design

For the dependent variables of number of emerged seedlings, number of surviving seedlings and biomass at a particular site and in a particular year, the following analysis of variance is given:

Source of Variation	Degrees of Freedom	
Block	2	
Treatment	15	
Mulch		3
Fertilizer		3
Mulch x Fertilizer		9
Error A	30	
Species	22	
Treatment x Species	330	
Species x Mulch		66
Species x Fertilizer		66
Species x Fertilizer x Mulch		198
Error B	704	
Total	1,103	

Environmental Data

Soils and climatic data will be collected periodically during the study period in order to attempt to establish more closely the causal links between plant response to varying treatments and the soil and climatic factors eliciting these responses. Soil moisture will be measured using standard gravimetric techniques from soil samples collected at 15 cm intervals throughout the soil column. Soil moisture determinations will be made periodically on three samples at each site during the growing season (Table 1).

Soil samples will be collected at each site and pH, exchangeable sodium percentage, available nitrogen, phosphorus, and potassium, electrical conductivity, percent organic matter, and concentrations of zinc and molybdenum will be determined with standard laboratory techniques. Two samples will be collected at each site during each growing season at 15 cm intervals.

Data Preparation and Data Submission

Data entry and data editing is performed through the use of a Mohawk Data Science (MDS) 2400 System. The following summarizes the hardware configuration (Figure 2):

1. MDS 2409-I Processor with 64K bytes of memory programmable in three languages.

2. One seven-track and three nine-track magnetic tape drives each 800 bpi density.

3. Two disc drives each with high density removable single discs.

4. Eight CRT display terminals.

5. Medium speed card reader (400 cpm).

6. Medium speed printer (600 lpm).

7. Communication capabilities to other installations (Figure 3).

All raw data will be available in duplicate on 7 or 9 track magnetic tapes, each 800 bpi, or standard 80 column punch cards. Data resulting from field surveys are entered at multiple computer keystations. The operating system for the keystations is designed to allow instantaneous validation of the biological data with regards to taxonomy. In addition, the physical and chemical data are verified and validated for acceptable limits.

Revegetation Trials in Years 2 and 3

Revegetation experiments initiated in Year Two (fall 1976) and Year Three (fall 1977) will essentially duplicate those initiated in Year One, except that a layer of Parahoe processed oil shale approximately 6 in. in thickness will be placed over the bedrock and below the simulated overburden. Comparison with Year One experiments should provide some insights into the effect of processed oil shale in revegetative success, particularly with regard to the influence of salt and heavy metals.

Trials 2 and 3 will be conducted on one site (as opposed to two in Trial 1) and will be monitored for a minimum of three years as is the case with Trial 1.

Additional experiments will be determined in conjunction with the Area Oil Shale Supervisor. They will depend in large on results obtained during the initial revegetation program and on the availability of actual processed oil shale. A number of other factors could be tested, such as the response of species to different soils, should data indicate large differences in site and vicinity soils. In the event that certain woody plants prove difficult to establish, it may be advisable to consider supplemental irrigation or perhaps direct outplantings or containerized seedlings.

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TABLE 1

SCHEDULE OF EVENTS FOR PHASE I REVEGETATION STUDIES ON OIL SHALE TRACT C-a
RIO BLANCO COUNTY, COLORADO, 1975 THROUGH 1978

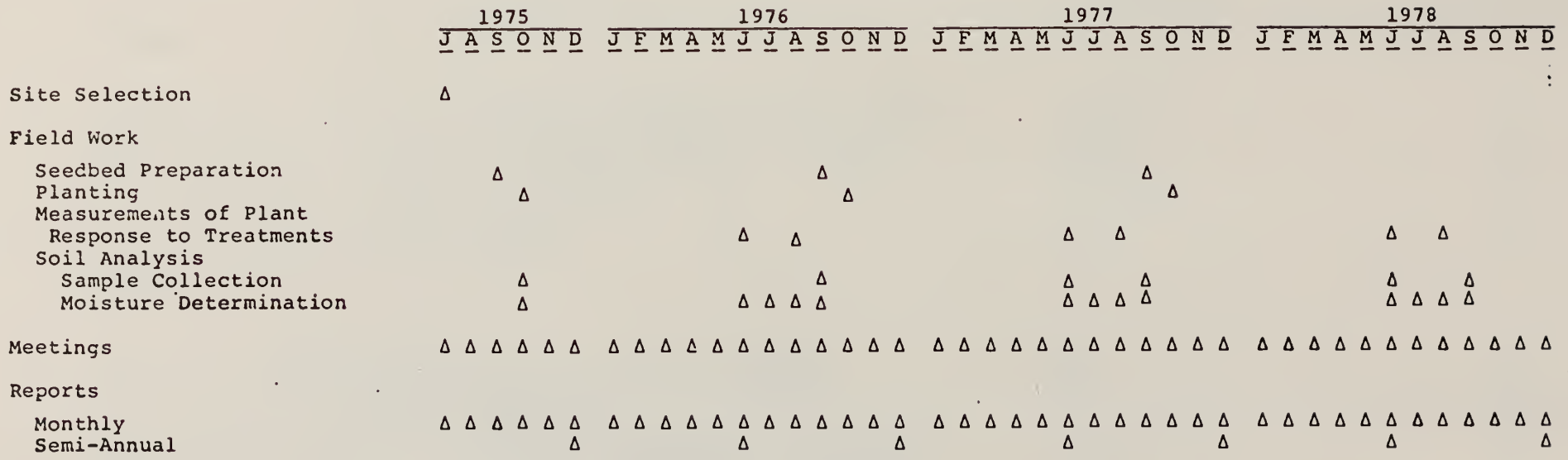


TABLE 2

PLANT SPECIES SUITABILITY AND RECOMMENDED SOWING RATES (lbs/acre) OF VIABLE SEED FOR SPECIES UTILIZED IN REVEGETATION EXPERIMENTS ON OIL SHALE TRACT C-a, RIO BLANCO COUNTY, COLORADO

Species	Suitability Rating[a]	1975 & 1976 Seeding Rates (lbs/acre)
GRASSES		
Luna pubescent wheatgrass (Agropyron trichophorum var. luna)	2,4,6,8,9	1.5
Rosana western wheatgrass (Agropyron smithii var. Rosana)	4,5,8,9	1.5
Sodar streambank wheatgrass (Agropyron riparium var. Sodar)	3,5,8,9	1.5
Indian ricegrass (Oryzopsis hymenoides)	2,4,5,7,9	0.6
C-43 basin wild rye (Elymus cinereus var. C-43)	2,4,5,7,11	1.5
Green needlegrass (Stipa viridula)	2,5,7	1.5
FORBS		
Lewis flax (Linum lewisii)	2,5	0.5
Lutana cicer milkvetch (Astragalus cicer var. Lutana)	6,11	0.5
Utah sweetvetch (Hedysarum utahensis)	2,5	0.5
Madrid yellow sweetclover (Melilotus officinalis var. Madrid)	2,4,5,9,11	0.5
Rocky Mountain penstemon (Penstemon strictus var. bandera)	3,5,9	0.5
Scarlet globemallow (Sphaeralcea coccinea)	3,5,9	0.5
SHRUBS		
Big sagebrush (Artemisia tridentata)	2,5,9,10,11	0.2
Little rabbitbrush (Chrysothamnus viscidiflorus)	2,4,5,9,11	0.2
Bitterbrush (Purshia tridentata)	1,5,9,10,11	1.0
Mountain mahogany (Cercocarpus montanus)	1,5,10	0.5
Fourwing saltbush (Atriplex canescens)	1(seeds), 3,4,5,9	1.0

TABLE 2 (Continued)

Species	Suitability Rating[a]	1975 & 1976 Seeding Rate (lbs/acre)
SHRUBS (Continued)		
Winterfat (Eurotia lanata)	1,5,10	0.5
Rubber rabbitbrush (Chrysothamnus nauseosus)	3,5,9,10,11	0.5
Snowberry (Symphoricarpos oreophilus)	2,4,5,10	0.5
Squaw bush (Rhus trilobata)	2,4,5,9,10,11	0.5
TREES		
Utah juniper (Juniperus osteosperma)	3,5,9,10,11	0.1
Pinyon pine (Pinus edulis)	3,5,9,11	0.1
	Total	16.5

[a] Suitability ratings are:

1	Highly palatable	7	Bunch grass
2	Moderately palatable	8	Sod grass
3	Unpalatable	9	Drought resistant
4	Soil stabilizer	10	Browse
5	Native to Colorado[b]	11	Cover for game
6	Introduced species		

[b] Underlining indicates species observed on site as part of the environmental baseline studies (Limnetics, Inc., June 1975).

TABLE 3

PLANT RESPONSE PARAMETERS MEASURED IN INITIAL REVEGETATION STUDIES ON OIL SHALE TRACT C-a, RIO BLANCO COUNTY, COLORADO, 1976-1978

Parameter	Time of Measurement	Taxa Involved
Number of emerged seedlings per plot	first spring following fall planting, i.e., beginning of first growing season	each planted species
Number of surviving seedlings per plot	end of first growing season	each planted species
Above-ground biomass (dry wt.)	end of third growing season	total seeded species, total alien species, individual seeded species contributing bulk of biomass
Percent cover	end of third growing season	each species
Vigor	end of first, second, and third growing seasons	each planted species

FIGURE 1

GULF - STANDARD (INDIANA)

RIO BLANCO OIL SHALE PROJECT

TRACT C-a

RIO BLANCO COUNTY, COLORADO

LEGEND

- TRACT OUTLINE
- DRILL HOLES
- STREAM GAGING STATIONS
- AIR QUALITY TOWERS
- ROADS
- X 1975 REVEGETATION TEST PLOTS

0 3000

FIGURE 2

DIAGRAM OF MOHAWK 2400 HARDWARE
ECOLOGICAL SCIENCES DIVISION
NUS CORPORATION

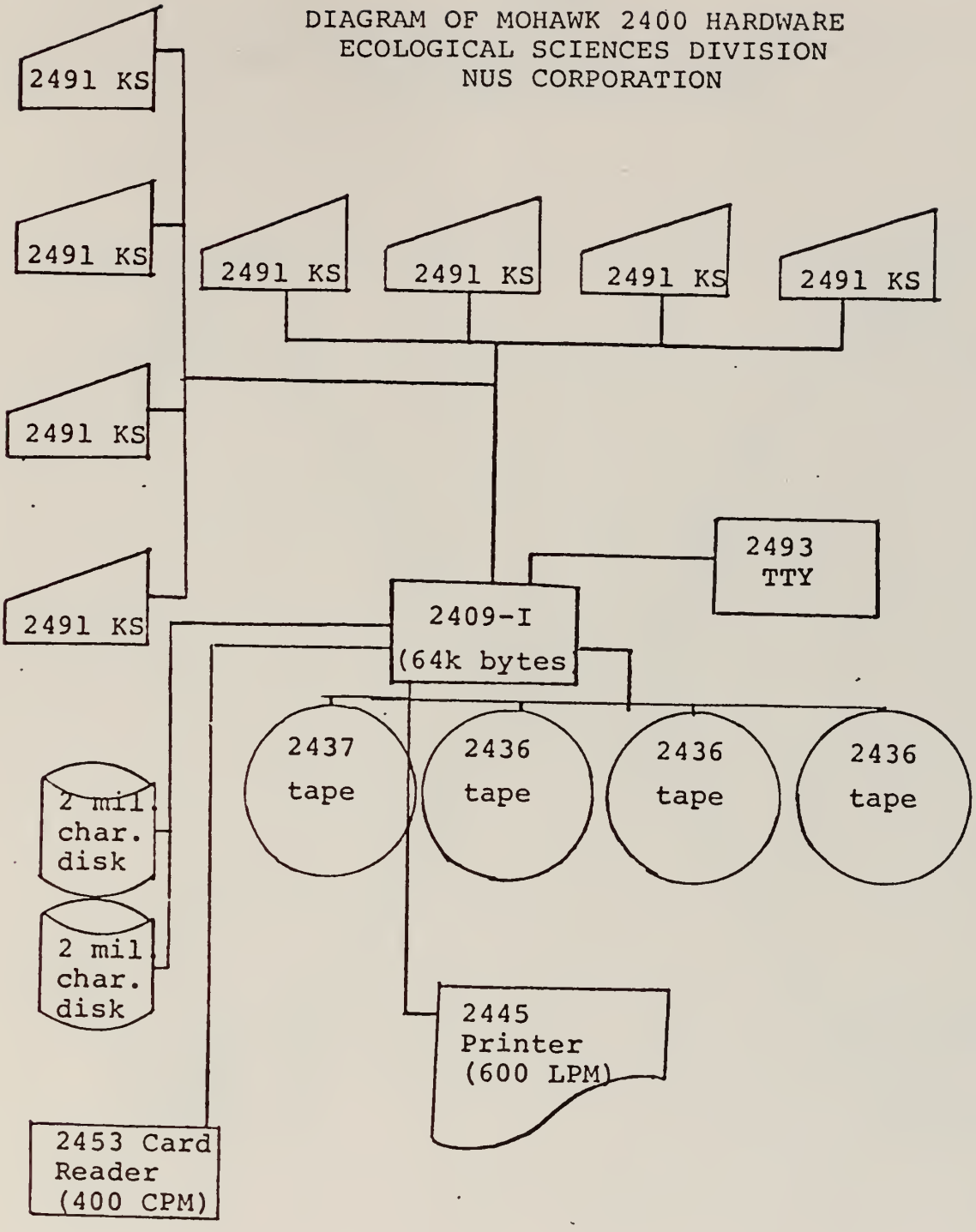
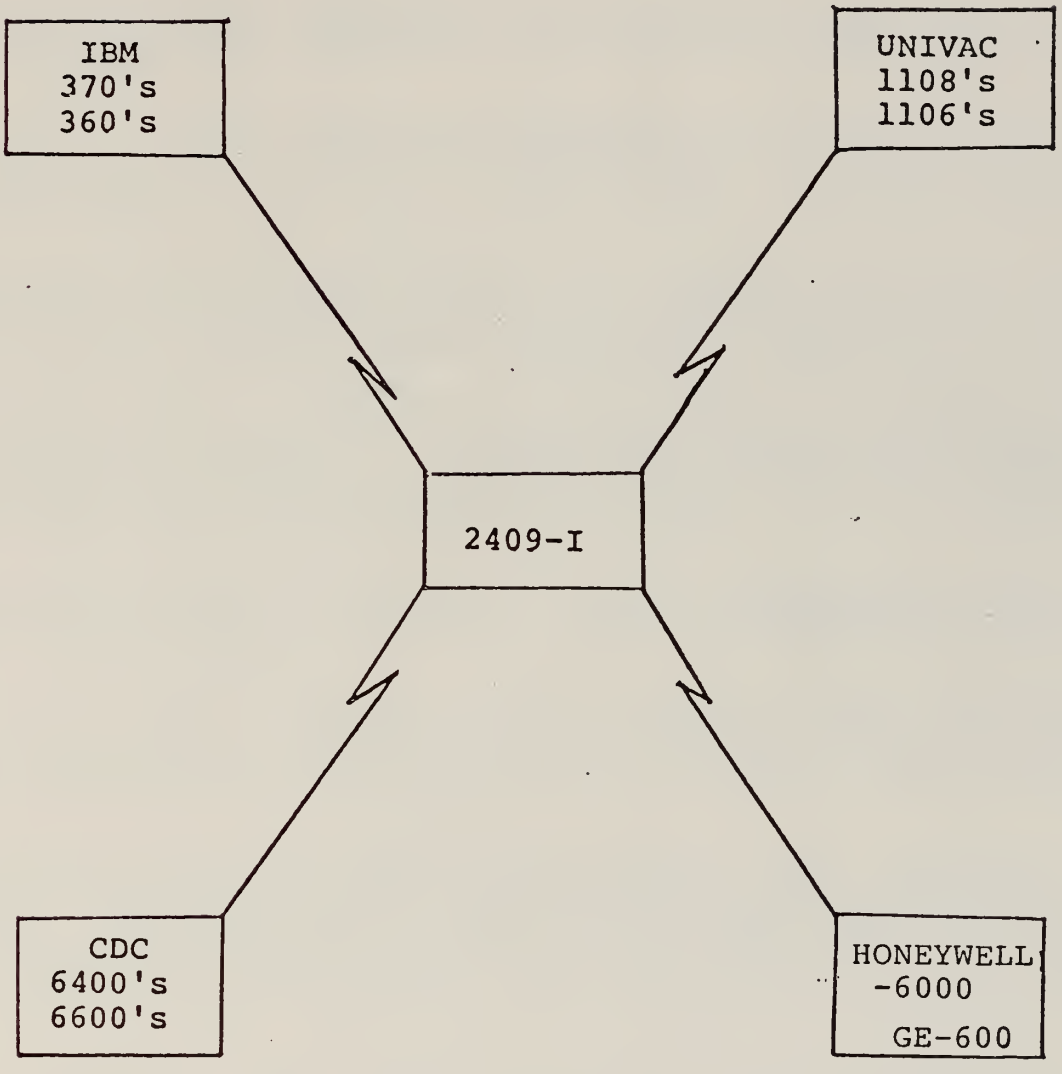


FIGURE 3

DIAGRAM OF MOHAWK 2400 COMMUNICATIONS LINK
WITH OTHER INSTALLATIONS



APPENDIX I

SELECTED BIBLIOGRAPHY OF LITERATURE PERTINANT TO REVEGETATION OF TRACT C-a

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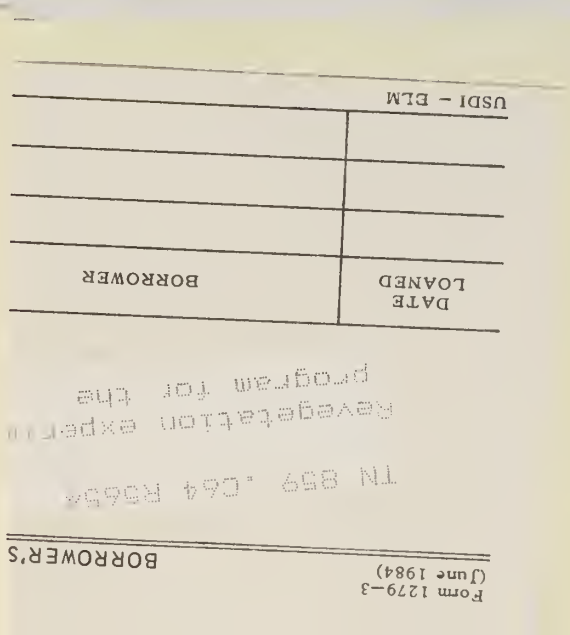
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